Electronic Fetal Monitoring in Relation to Cesarean Section Delivery, for Live Births and Stillbirths in the U.S., 1980

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This paper was presented on November 16, 1983, at the 111th annual meeting of the American Public Health Association in Dallas, Tex.

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Synopsis

In the 1980 National Natality and Fetal Mortality Surveys, information about fetal monitoring and type of delivery was obtained from hospitals for a sample of 9,941 live births and 6,386 fetal deaths of 28 weeks' gestation or more. Data in this analysis are weighted to provide national estimates of live births and late fetal deaths that occurred in U.S. hospitals during 1980. Electronic fetal monitoring (EFM) was used for 47.7 percent of live births; 27.2 percent were monitored by Doppler ultrasound only, 10.2 percent by scalp electrode only, 6.3 percent by Doppler ultrasound and scalp electrode only, and 4.0 percent by other methods and combinations. The distribution by type of EFM used was similar for the 42.7 percent of late fetal deaths (also called stillbirths) that were monitored. Variation in the use of EFM for live births and stillbirths is examined according to maternal age, parity, education, race, marital status, income, previous fetal loss, underlying medical conditions, complications of pregnancy, complications of labor, duration of labor, infant birth weight, and length of gestation.

Among live births, 17.1 percent were delivered by cesarean section, as were 16.8 percent of stillbirths. The association between fetal monitoring and the primary cesarean section rate (the probability of cesarean section for women who had never had one) for all birth orders and for first births is examined according to characteristics of the mothers and the infants. Factors involved in the consistent association found between fetal monitoring and the primary cesarean section rate are discussed.

ELECTRONIC FETAL MONITORING (EFM) was introduced about 1960. Its use has increased dramatically in the past decade (*1,2*), as has the rate of cesarean section delivery (*3–8*). Has the increased use of EFM contributed to the rising cesarean section rate? These two procedures have been successfully used to improve pregnancy outcome, but concern has been expressed over the increasing use of electronic technology and surgery in the birthing process (*9*). A medically precise description of electronic fetal monitoring (*10*) follows:

> The electronic fetal monitor provides automated instrumentation for continuous data acquisition of the vital signs of the fetus in terms of its heart rates and their changes in response to the stress of labor contractions. Most fetal monitors have the capability of obtaining the fetal heart rate through either direct (internal) or indirect (external) methods. In the direct method, the fetal electrocardiogram (FECG) is obtained with the use of an electrode which is attached to the fetal presenting part after the amniotic sac has been ruptured. The indirect method involves the use of a phono transducer, ultrasound transducer or electrocardiogram electrodes on the maternal abdomen to detect the fetal heart beats. The choice of technique is generally determined by clinical requirements and more than one technique may be used sequentially.

Researchers are divided on the question whether the increased use of EFM has contributed to the rising cesarean section rate. On the one hand, a comprehensive but controversial report by Banta and Thacker (*11*) concluded that EFM increases the cesarean section rate, partly because false indications of fetal distress from EFM are frequent. Futhermore, after a comprehensive review of the available data, Marieskind (*12*) concluded:

> While inexperience with EFM undoubtedly leads to some false-positive diagnoses of fetal distress and subsequent C-sections, the data do not generally support the idea that EFM is to blame for the rise. Rather, the use of technology seems in and of itself conducive to using more technology and increased cesarean sections are a logical outcome of this perspective. Data from hospitals with no electronic fetal monitoring also show an increase in C-sections and support this view.

The Office of Technology Assessment concluded that "although many believe that electronic fetal monitoring

is useful, its relative efficacy and benefit have not been established'' (*13*).

Finally, the National Institutes of Health Consensus Development Conference on Cesarean Childbirth concluded that there have been fundamental changes in obstetrical practice, an increased use of EFM and other new technologies, and more frequent diagnoses of dystocia (difficult labor). The conference reviewed five types of studies in which the relationship between electronic fetal monitoring and cesarean delivery rates was examined, and in most of these studies a higher cesarean rate was found among women who were electronically monitored (*14*).

This article explores the relationship between EFM and cesarean section delivery in the United States, according to demographic and health characteristics of mothers and infants, for live births and stillbirths.

Data Sources

Data for live births were obtained from the 1980 National Natality Survey (NNS), a nationally representative survey that provides information on obstetrical practices for mothers who bore live infants in 1980 in the United States. Data for stillbirths (late fetal deaths after 28 weeks or more of gestation) were obtained from the 1980 National Fetal Mortality Survey (NFMS), a nationally representative survey that provides information on obstetrical practices for mothers who bore stillborn infants in 1980 in the United States. Information for the sample delivery was obtained from the vital record, the mother, the hospital where her delivery occurred, her attendant at delivery, the physician providing prenatal care, and other providers of radiation examinations and treatments. The details of survey design and sampling techniques are discussed in the article introducing this section of the journal (pp. 111–116).

EFM and cesarean section information was collected from a questionnaire, mailed to hospitals, that contained these questions:

Was electronic fetal monitoring (EFM) used in the management of this pregnancy? Yes_____. No_____. If yes, which of the following types of EFM was performed? Check all that apply. Doppler ultrasound (external)_____. Scalp electrode (internal)_____. Other (specify)_____.

Information on type of delivery was obtained from a checklist:

Type of delivery: check *one* only: Normal spontaneous_____. Forceps—low_____. Forceps—mid_____. Forceps—high_____. Normal, vacuum extractor_____. Breech_____. First cesarean section_____. Repeat cesarean section_____. Other (specify)_____.

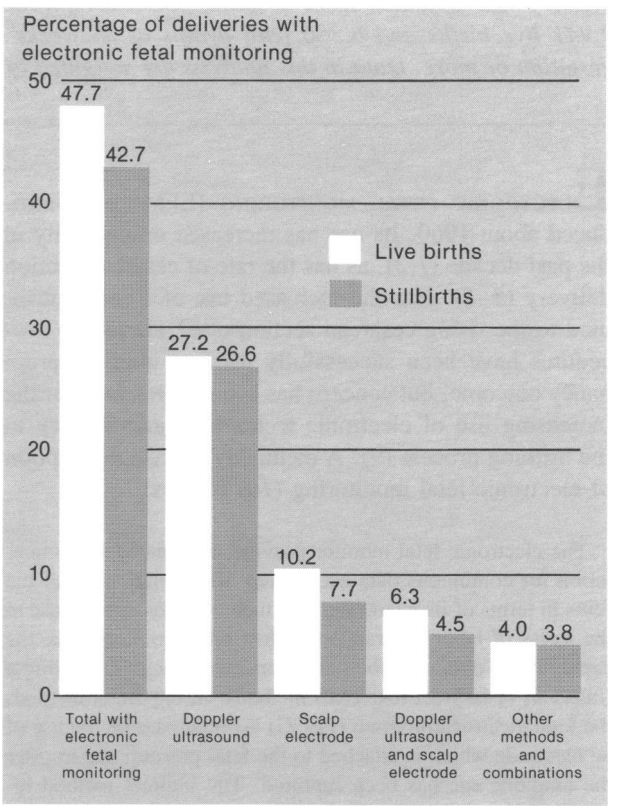
Statistics that follow pertain only to in-hospital deliveries of live births and stillbirths; missing data because of nonresponse were imputed, and all data have been weighted to reflect national estimates.

EFM and Type of Delivery

Figure 1 shows that EFM was used for nearly half of live hospital births and stillborn hospital deliveries. EFM was employed for 47.7 percent of live births; 27.2 percent were monitored by Doppler ultrasound only (external), 10.2 percent by scalp electrode only (internal), 6.3 percent by Doppler ultrasound and scalp electrode, and 4.0 percent by other methods and combinations of EFM. The use of EFM was generally lower for stillbirths; overall, EFM was used for 42.7 percent of stillborn deliveries.

Figure 2 shows the percentage distribution of live births and stillbirths by type of delivery. Of live hospital births, 62.4 percent were normal spontaneous deliveries, 17.4 percent were forceps deliveries, 1.0 percent were breech deliveries, 10.5 percent were primary cesarean deliveries, 6.6 percent were repeat cesarean deliveries,

Figure 1. Percentage of live hospital births and stillborn hospital deliveries with electronic fetal monitoring: United States, 1980



SOURCE: National Center for Health Statistics: data on live births from the 1980 National Natality Survey and on stillbirths from the 1980 National Fetal Mortality Survey.

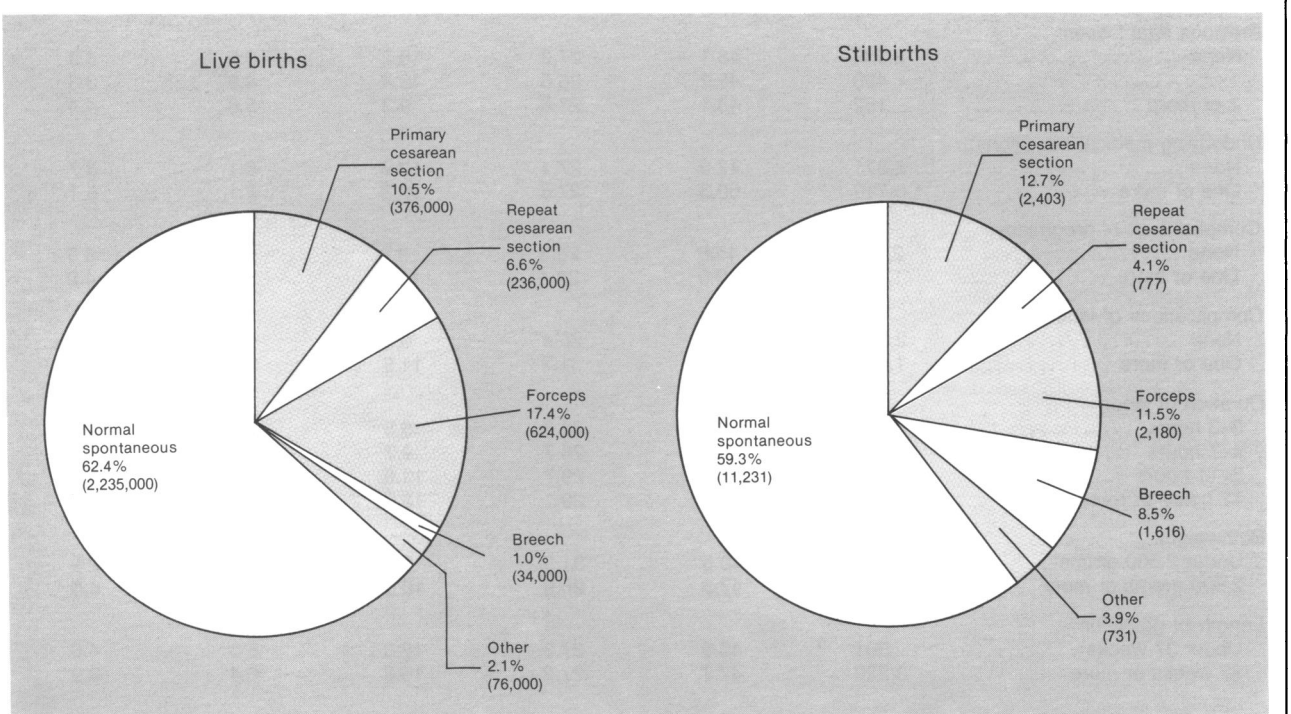
and 2.1 percent were other types of delivery. Of stillborn hospital births, 59.3 percent were spontaneous deliveries, 11.5 percent were forceps deliveries, 8.5 percent were breech deliveries, 12.7 percent were primary cesarean deliveries, 4.1 percent were repeat cesarean deliveries, and 3.9 percent were other types of delivery. Notably, stillborn infants were much more likely than infants born alive to be delivered breech, and slightly more likely to be delivered by primary cesarean section.

Table 1 shows EFM in relation to characteristics of mothers and their live-born infants. EFM was more likely to be used for mothers with no previous live births than for mothers with two or more previous live births; for unmarried mothers than for married mothers; and for mothers with one or more underlying medical conditions, one or more complications of pregnancy, or one or more complications of labor than for mothers who had none of these. Finally, EFM was more frequently used for mothers who were in labor for 4 hours or more than for mothers in labor 0–3 hours. All these comparisons were statistically significant at the .05 level.

(Maternal complications and conditions data were obtained from a checklist on the questionnaire mailed to hospitals. Underlying medical conditions included varicosity; congenital heart disease; thyroid condition; obesity; anemia; cardiovascular-renal disease; asthma; other chronic pulmonary conditions; orthopedic conditions; Rh incompatibility; sickle cell anemia; alcoholism; other drug abuse; diabetes—gestational only; diabetes—juvenile; diabetes—adult onset type; and other conditions, not specified. Complications of pregnancy included urinary infection; hypertension; toxemia preeclampsia; eclampsia; anemia; rubella; embolism; obesity; inadequate weight gain; excessive weight gain; abnormal position of placenta [placenta previa]; abnormal position of cord; and other conditions, not specified. Complications of labor included inadequate pelvis; transverse lie; multiple birth; abnormal position of placenta or cord; premature rupture of membranes; unusual bleeding; prolonged labor; anesthesia reaction; placenta abruptio; hypertension; toxemia preeclampsia; eclampsia; embolism; and other conditions, not specified.)

There was no statistically significant variation in the use of EFM by maternal race, family income, previous fetal loss, infant birth weight, and length of gestation. The pattern of association between specific types of EFM and these characteristics was similar to the pattern for EFM overall except that low birth weight infants (under 2,500 grams or 5 pounds 8 ounces) were more likely to be monitored by Doppler ultrasound only than were higher birth weight infants. More striking than the variation in EFM associated with different characteristics, however, was the relative uniformity in EFM

Figure 2. Percentage distribution of live hospital births and stillborn hospital deliveries by type of delivery: United States, 1980



SOURCE: National Center for Health Statistics: preliminary data on live births from the 1980 National Natality Survey and on stillbirths from the 1980 National Fetal Mortality Survey.

Table 1. Percentage of in-hospital live births where electronic fetal monitoring was used, by characteristics of mothers and infants: United States, 1980

Characteristics	Number in thousands	Electronic fetal monitoring				
		Total	Doppler only	Scalp electrode only	Doppler and scalp electrode only	Other
Total	3,581	47.7	27.2	10.2	6.3	4.0
Age of mother:						
< 20 years	558	49.3	26.6	11.5	7.0	4.3
20–24 years	1,218	49.7	27.6	11.5	6.7	4.0
25–29 years	1,097	47.3	27.6	9.6	5.9	4.2
30 years and over	708	43.3	26.4	7.8	5.8	3.3
Education of mother:						
0–11 years	825	45.1	25.5	9.8	6.1	3.7
12 years	1,579	48.1	27.8	10.3	5.8	4.2
13 years or more	1,177	48.8	27.6	10.3	7.1	3.8
Race of mother:						
White	2,910	47.3	27.3	10.4	5.9	3.7
Black	559	49.0	25.5	10.1	8.3	5.1
Marital status of mother:						
Married	2,921	46.9	27.3	9.7	6.0	4.0
Not married	659	50.9	26.8	12.5	7.8	3.8
Family Income:[1]						
Under $15,000	1,058	46.9	27.6	9.7	5.9	3.7
$15,000–$29,999	1,424	46.4	27.3	9.4	5.8	3.9
$30,000 or more	440	48.5	26.7	10.5	6.6	4.8
Previous live births:						
None	1,553	54.1	28.5	12.8	8.3	4.6
1	1,147	45.0	27.7	8.8	5.3	3.2
2 or more	881	39.7	24.3	7.5	4.1	3.7
Previous fetal losses:						
None	2,939	48.1	27.3	10.2	6.6	4.0
1	490	45.2	26.6	10.4	4.9	3.3
2 or more	152	46.1	26.6	9.3	5.8	4.4
Underlying medical conditions:						
None	2,871	47.0	27.1	10.2	6.1	3.7
One or more	710	50.3	27.8	10.3	7.1	5.1
Complications of pregnancy:						
None	2,535	45.8	26.3	9.9	6.1	3.5
One or more	1,045	52.0	29.4	10.8	6.9	4.9
Complications of labor:						
None	2,538	44.3	25.4	9.5	5.6	3.8
One or more	1,043	55.8	31.7	11.9	7.9	4.3
Duration of labor:						
0–3 hours	781	36.6	23.6	6.5	3.5	3.0
4–7 hours	1,211	46.4	26.7	9.7	5.9	4.2
8–11 hours	734	54.1	29.7	12.6	7.9	3.9
12 hours or more	854	54.0	29.1	12.2	8.2	4.5
Birthweight:						
Under 2,500 grams	248	49.5	31.5	8.5	6.7	2.9
2,500 grams or more	3,333	47.5	26.9	10.3	6.3	4.0
Length of gestation:						
Under 37 weeks	361	46.9	27.3	10.3	5.3	4.0
37 weeks or more	3,220	47.7	27.2	10.2	6.4	3.9

[1] Family income is for married mothers only.

Table 2. Percentage of in-hospital stillbirths where electronic fetal monitoring was used, by characteristics of mothers and infants: United States, 1980

Characteristics	Number	Electronic fetal monitoring				
		Total	Doppler only	Scalp electrode only	Doppler and scalp electrode only	Other
Total	18,939	42.7	26.6	7.7	4.5	3.8
Age of mother:						
< 20 years	2,930	43.6	27.0	7.6	5.1	3.9
20–24 years	5,910	43.0	27.1	8.0	4.6	3.4
25–29 years	5,142	43.3	26.3	7.9	4.7	4.4
30 years and over	4,957	41.1	26.2	7.3	3.7	3.8
Education of mother:						
0–11 years	5,152	40.6	25.6	6.9	4.4	3.8
12 years	8,651	43.8	27.4	8.8	4.0	3.6
13 years or more	5,135	42.8	26.5	6.7	5.3	4.3
Race of mother:						
White	14,275	43.0	26.8	7.8	4.5	3.8
Black	4,181	41.4	25.5	7.6	4.5	3.8
Marital status of mother:						
Married	14,633	43.4	27.0	7.8	4.4	4.2
Not married	4,305	40.2	25.5	7.3	4.7	2.7
Family Income:[1]						
Under $15,000	5,697	43.7	26.9	7.7	4.8	4.4
$15,000–$29,999	6,816	43.0	26.9	7.8	4.1	4.2
$30,000 or more	2,121	43.9	27.5	8.2	4.6	3.6
Previous live births:						
None	8,824	44.4	28.1	7.9	4.8	3.7
1	4,706	43.2	27.4	7.5	4.6	3.7
2 or more	5,409	39.5	23.7	7.6	3.9	4.3
Previous fetal losses:						
None	15,004	43.1	26.9	7.7	4.4	4.1
1	2,802	40.8	25.4	7.8	4.4	3.2
2 or more	1,133	41.9	26.4	8.2	5.1	[2]2.1
Underlying medical conditions:						
None	13,492	42.2	26.4	7.6	4.3	3.9
One or more	5,447	43.8	27.1	8.0	5.0	3.8
Complications of pregnancy:						
None	9,958	41.5	25.0	8.0	4.6	3.9
One or more	8,981	44.0	28.5	7.3	4.4	3.8
Complications of labor:						
None	7,954	37.4	23.5	7.0	3.3	3.7
One or more	10,985	46.5	29.0	8.2	5.3	4.0
Duration of labor:						
0–3 hours	4,585	39.8	24.2	7.2	4.5	3.9
4–7 hours	6,370	41.3	25.7	8.2	3.9	3.5
8–11 hours	3,560	43.7	27.8	7.6	4.8	3.6
12 hours or more	4,423	46.8	29.5	7.6	5.1	4.6
Birthweight:						
Under 2,500 grams	10,463	39.7	26.6	5.7	3.8	3.5
2,500 grams or more	8,476	46.4	26.7	10.1	5.3	4.2
Length of gestation:						
Under 37 weeks	8,570	39.4	26.6	5.8	3.6	3.4
37 weeks or more	10,369	45.4	26.7	9.3	5.2	4.2

[1] Family income is for married mothers only.
[2] Figure does not meet standards of reliability or precision; that is, the relative standard error is 25 percent or more.

use associated with most maternal and infant characteristics.

Table 2 presents similar EFM information for stillbirths and shows that 42.7 percent of stillbirths were monitored by EFM, compared with 47.7 percent of live births. About the same proportion of stillbirths as live births were monitored by Doppler ultrasound (26.6 percent and 27.2 percent), but stillbirths were less likely than live births (7.7 percent versus 10.2 percent) to be monitored by scalp electrode only, and less likely than live births (4.5 percent versus 6.3 percent) to be monitored by Doppler ultrasound and scalp electrode only. The slightly lower use of EFM with stillbirths is accounted for by the fact that stillbirths tended to be of shorter gestation and that scalp electrode monitoring was less frequently used for preterm stillbirths (less than 37 weeks' gestation) than for full-term stillbirths. In stillbirths, however, fetal demise usually occurs before labor, so EFM may be used to confirm the fact of fetal death. In this sense, EFM use for stillbirths would not seem readily comparable to EFM use for live births. Yet the patterns of EFM usage were remarkably similar for live births and stillbirths. There was even greater similarity of EFM use when live-born and stillborn infants had reached 37 weeks or more of gestation.

Certain types of delivery were more likely if EFM was used, and the same patterns occurred for live births and stillbirths (table 3). Primary cesarean section delivery (the woman's first cesarean section, even though she might have been having a first, second, or higher order birth) was more likely if EFM was used. When EFM was not used, only 8.9 percent of live-born infants were delivered by primary cesarean section; when EFM was used, 12.2 percent of live births were by primary cesarean. This might be expected, since EFM detects fetal distress, in which case a cesarean section is often indicated. Of course, there are indications for primary cesarean that do not depend on fetal problems identified during the process of labor. Among these are severe diabetes and pelvic deformities that render vaginal delivery impossible.

On the other hand, repeat cesarean sections were negatively associated with EFM. When EFM was not used, 9.1 percent of live-born infants were delivered by repeat cesarean; however, when EFM was used, only 3.9 percent were. Repeat cesareans are usually scheduled,

Table 3. Percentage distribution of in-hospital live births and stillbirths by type of delivery and electronic fetal monitoring (EFM) usage: United States, 1980

Birth outcome and type of delivery	All deliveries	No EFM	EFM				
			Total	Doppler only	Scalp electrode only	Doppler and scalp electrode only	Other
Live births							
Number	3,581,000	1,874,000	1,706,000	974,000	365,000	226,000	142,000
Type of delivery:							
Cesarean section	17.1	18.0	16.1	17.5	13.6	14.5	15.3
Primary	10.5	8.9	12.2	13.0	11.1	12.1	10.4
Repeat	6.6	9.1	3.9	4.6	2.5	[1]2.4	4.9
Normal spontaneous	62.4	64.5	60.1	60.9	60.1	57.7	58.4
Forceps	17.4	14.5	20.7	18.7	23.7	24.4	20.4
Breech	1.0	1.2	0.7	[1]0.6	[1]0.4	[1]0.8	[1]1.2
Other	2.1	1.8	2.5	2.3	2.1	[1]2.6	4.6
Stillbirths							
Number	18,939	10,856	8,083	5,046	1,461	848	728
Type of delivery:							
Cesarean section	16.8	15.0	19.2	19.2	17.6	21.0	20.1
Primary	12.7	10.7	15.4	15.0	15.5	18.5	14.3
Repeat	4.1	4.3	3.8	4.2	[1]2.1	[1]2.5	[1]5.8
Normal spontaneous	59.3	60.9	57.2	57.9	58.2	53.9	54.2
Forceps	11.5	10.4	12.9	11.8	15.5	15.4	13.0
Breech	8.5	9.4	7.3	7.9	4.7	6.8	9.6
Other	3.9	4.2	3.4	3.3	4.0	[1]2.9	[1]3.0

[1] Figure does not meet standards of reliability or precision; that is, the relative standard error is 25 percent or more.

and may take place before labor starts; hence, EFM is not used. (Repeat cesareans are frequently done because of the "once a section, always a section" obstetrical norm rather than because of other maternal or fetal indications.)

Primary cesarean section delivery was also more likely for stillbirths if EFM was used. Particularly where fetal death occurred before labor, reasons for using EFM for stillbirths may have been very different from reasons for using it with live births. If the EFM detected fetal demise, the cesarean section may have been done simply to end the pregnancy as soon as possible. Furthermore, cesarean delivery may have been used in some instances of fetal distress and impending fetal demise, as identified by intrapartum EFM. There is evidence that this is often the case. According to 1980 NFMS data from the Report of Fetal Death, 82.8 percent of fetal deaths occurred before labor, 14.6 percent occurred during labor, and 2.5 percent occurred during delivery. Given that the rationale for EFM use and subsequent cesarean sections is different for stillbirths than for live births, NFMS data must be interpreted cautiously.

Since EFM is *positively* associated with primary cesarean sections but *negatively* associated with repeat cesareans, the net effect is to cancel out the relationship of EFM to cesarean sections overall. The implication of this is that one must separate primary and repeat cesareans when studying their relationship to EFM.

Note also that normal spontaneous deliveries were more likely if EFM was not used, and that forceps deliveries were more likely if EFM was used. There has been a reduction in the use of forceps during delivery, from 37 percent of live births in 1972 to 18 percent in 1980 (*7*). It is likely that this change in obstetrical practice represents an effort by physicians to reduce the number of particularly difficult forceps deliveries because of the high risk of birth injury to the fetus. Finally, breech deliveries were less likely to occur if EFM was used, and this may have been due to the fact that a cesarean section was likely to be done if the fetus presented breech. This interpretation is supported by other studies which have shown that the obstetrical management of breech presentations has changed over the past decade. In 1970, only 15 percent of breech presentations resulted in cesarean sections; however, by 1978, 60 percent of breech presentations did so (*15*). By 1980, 67 percent of breech presentations resulted in cesarean sections (*16*).

Primary Cesarean Delivery Rates

Since we found EFM to be positively related to primary cesarean section delivery, and since other National Natality Survey research (*7*) has shown that first-order live births are three times more likely to occur by primary cesarean section than are second or higher order births, our concluding effort in this analysis was to examine primary cesarean section rates by EFM, according to maternal and infant characteristics for all birth orders combined and for first deliveries only, for both live births and stillbirths (tables 4 and 5).

To study primary cesarean section rates more precisely, it is desirable to remove repeat cesareans from the denominator. Others (*17–19*) have also suggested that, because of the common obstetrical practice of repeating cesareans automatically, a clearer picture of the risk of first cesarean delivery is obtained by excluding repeat cesareans from the denominator. Primary cesarean rates are calculated by dividing the number of first cesareans by all deliveries less repeat cesareans. In 1980, 612,000 cesarean deliveries of live infants occurred; 236,000 (38.6 percent) of these were repeat cesareans and 376,000 (61.4 percent) were first cesareans. The primary cesarean rate for all orders of live hospital births (table 4) was calculated as follows: $376{,}000 \div (3{,}581{,}000 - 236{,}000) \times 100$ equals 11.2. Of hospital stillbirths in 1980, 3,180 were by cesarean delivery, and 777 (24.4 percent) were by repeat cesarean. By similar calculation, the primary cesarean rate for all orders of stillborn hospital deliveries was 13.2 (table 5). The risk of a primary cesarean is thus defined as the number of first cesarean sections per 100 deliveries to mothers who have never before had a cesarean.

The primary cesarean rate for all live births, when EFM was used, was 12.7; when EFM was not used, the rate was 9.8 (table 4). For most of the 35 comparisons of maternal and infant characteristics for all birth orders combined, the primary cesarean rate was higher when EFM was used. The 21 comparisons that are statistically significant at the .05 level are indicated in the table. For only two characteristics—mother's age 30 or more and mothers with two or more previous fetal losses—did this relationship reverse. The primary cesarean rate for mothers having first live births was 17.61—18.7 when EFM was used and 16.4 when it was not. Again, for most of the 31 comparisons of maternal and infant characteristics, the primary cesarean rate was higher when EFM was used. However, because of small sample size and sampling variability, only six of these comparisons are statistically significant at the .05 level. In summary, with respect to first live births and births of all orders, EFM was almost always associated with a higher probability of primary cesarean section delivery, although statistical significance was not always attained.

Table 5 presents primary cesarean section rates for stillbirths and shows that the primary rate for all stillbirths was 13.2; the rate was 16.0 when EFM was used and 11.2 when it was not. A higher primary cesarean rate

Table 4. Primary cesarean section rates for in-hospital live births, by maternal and infant characteristics and electronic fetal monitoring (EFM) usage: United States, 1980

Characteristics	Rates[1] for all live births				Rates[1] for first live births[2]			
	Total	EFM	No EFM	P value[3]	Total	EFM	No EFM	P value[3]
Total	11.2	12.7	9.8	≤ .05	17.6	18.7	16.4	
Age of mother:								
< 20 years	12.7	14.2	11.3		15.5	18.2	12.8	≤ .05
20–24 years	9.8	11.2	8.4	≤ .05	15.0	15.7	14.1	
25–29 years	12.1	15.0	9.3	≤ .05	21.2	22.8	19.0	
30 years or more	11.1	10.5	11.7		28.2	22.8	33.2	
Education of mother:								
0–11 years	10.1	12.1	8.3	≤ .05	16.0	19.4	12.6	≤ .05
12 years	10.9	12.2	9.6	≤ .05	16.5	16.9	16.1	
13 years or more	12.6	13.9	11.3		20.2	20.5	19.7	
Race of mother:								
White	11.1	12.3	10.1	≤ .05	17.6	18.4	16.6	
All other	11.7	14.6	8.7	≤ .05	17.9	20.1	15.3	
Black	11.1	13.7	8.6	≤ .05	16.8	18.4	15.0	
Marital status of mother:								
Married	11.0	12.1	10.0	≤ .05	18.0	18.1	17.8	
Not married	12.3	15.4	9.0	≤ .05	16.6	20.4	12.2	≤ .05
Family income:[4]								
Under $15,000	9.7	11.1	8.4	≤ .05	17.0	17.9	15.9	
$15,000–$29,999	11.1	12.1	10.1		17.4	17.0	17.9	
$30,000 or more	13.8	14.0	13.5		21.8	21.9	21.6	
Previous live births:								
None	17.6	18.4	16.7		17.6	18.7	16.4	
1	5.1	6.0	4.2	≤ .05	NA	NA	NA	
2 or more	6.7	7.9	5.8		NA	NA	NA	
Previous fetal losses:								
None	11.4	13.1	9.8	≤ .05	17.6	18.7	16.4	
1	10.3	11.2	9.5		NA	NA	NA	
2 or more	11.2	10.3	12.0		NA	NA	NA	
Underlying medical conditions:								
None	10.7	12.4	9.1	≤ .05	16.9	18.3	15.3	≤ .05
1 or more	13.4	14.1	12.8		21.5	20.5	23.0	
Complications of pregnancy:								
None	9.1	10.3	8.1	≤ .05	15.0	16.0	13.9	
1 or more	16.4	18.0	14.6	≤ .05	23.5	23.5	23.5	
Complications of labor:								
None	4.1	4.1	4.0		6.8	7.0	6.5	
1 or more	28.3	29.1	27.2		35.3	34.2	36.9	
Duration of labor:								
0–3 hours	14.0	14.5	13.7		27.7	26.0	29.3	
4–7 hours	6.3	7.0	5.8		11.2	11.5	11.0	
8–11 hours	10.5	12.2	8.4	≤ .05	14.4	15.5	12.9	
12 hours or more	16.8	19.2	13.9	≤ .05	22.1	24.2	19.2	≤ .05
Birth weight:								
Under 2,500 grams	21.5	22.8	20.3		26.6	27.2	26.0	
2,500 grams or more	10.5	12.0	9.0	≤ .05	17.0	18.1	15.7	
Length of gestation:								
Less than 37 weeks	14.1	18.2	10.4	≤ .05	17.9	22.5	12.7	≤ .05
37 weeks or more	10.9	12.1	9.7	≤ .05	17.6	18.3	16.8	

[1] Rates are first cesarean deliveries per 100 deliveries, excluding all repeat cesareans.

[2] Analysis restricted to women with no previous fetal losses.

[3] Denotes a statistically significant difference across categories for the "EFM" and "No EFM" comparisons.

[4] Family income is for married mothers only.

NOTE: NA = not applicable.

Table 5. Primary cesarean section rates for in-hospital stillbirths, by maternal and infant characteristics and electronic fetal monitoring (EFM) usage: United States, 1980

Characteristics	Rates[1] for all stillbirths				Rates[1] for first deliveries			
	Total	EFM	No EFM	P value[2]	Total	EFM	No EFM	P value[2]
Total	13.2	16.0	11.2	≤ .05	13.6	17.2	10.7	≤ .05
Age of mother:								
< 20 years	11.7	15.2	9.0	≤ .05	11.0	14.8	7.7	≤ .05
20–24 years	12.6	14.9	10.8	≤ .05	13.4	16.0	11.3	
25–29 years	13.3	16.9	10.5	≤ .05	15.2	20.3	11.3	≤ .05
30 years or more	14.9	17.0	13.4		18.4	22.5	15.6	
Education of mother:								
0–11 years	12.1	14.5	10.4	≤ .05	12.1	14.9	10.0	
12 years	13.6	15.6	12.0	≤ .05	13.3	14.9	12.1	
13 years or more	13.9	18.2	10.6	≤ .05	15.5	23.3	9.2	≤ .05
Race of mother:								
White	13.9	16.8	11.7	≤ .05	14.8	18.8	11.7	≤ .05
All other	11.3	13.4	9.7		9.2	11.6	7.4	
Black	11.7	14.2	9.9		9.4	12.2	7.2	
Marital status of mother:								
Married	13.9	16.6	11.9	≤ .05	15.5	18.8	12.7	≤ .05
Not married	10.8	13.9	8.7	≤ .05	9.1	13.0	6.3	≤ .05
Family income:[3]								
Under $15,000	13.9	16.1	12.1		16.2	19.0	13.7	
$15,000–$29,999	13.7	17.1	11.0	≤ .05	14.8	19.0	11.3	≤ .05
$30,000 or more	15.0	16.1	14.2		15.8	17.3	14.8	
Previous live births:								
None	13.3	16.9	10.5	≤ .05	13.6	17.2	10.7	
1	11.9	15.1	9.5	≤ .05	NA	NA	NA	
2 or more	14.1	15.1	13.5		NA	NA	NA	
Previous fetal losses:								
None	13.1	15.7	11.2	≤ .05	13.6	17.2	10.7	
1	13.3	17.1	10.6	≤ .05	NA	NA	NA	
2 or more	14.3	17.0	12.4		NA	NA	NA	
Underlying medical conditions:								
None	13.0	15.8	11.0	≤ .05	12.8	15.9	10.4	≤ .05
1 or more	13.7	16.4	11.6	≤ .05	16.0	20.9	11.8	≤ .05
Complications of pregnancy:								
None	12.1	14.2	10.6	≤ .05	12.3	15.3	10.0	≤ .05
1 or more	14.5	17.9	11.9	≤ .05	15.2	19.4	11.7	≤ .05
Complications of labor:								
None	5.8	7.0	5.1		5.6	6.9	4.8	
1 or more	18.7	21.3	16.4	≤ .05	20.1	23.9	16.4	≤ .05
Duration of labor:								
0–3 hours	21.1	25.8	18.0	≤ .05	23.8	31.9	18.4	≤ .05
4–7 hours	9.0	11.2	7.4	≤ .05	8.0	12.2	4.8	≤ .05
8–11 hours	10.1	12.1	8.6		11.2	11.2	11.2	
12 hours or more	14.4	17.1	12.1	≤ .05	14.6	17.9	11.3	≤ .05
Birth weight:								
Under 2,500 grams	11.4	14.2	9.6	≤ .05	10.9	14.6	8.3	≤ .05
2,500 grams or more	15.5	17.9	13.3	≤ .05	17.1	19.9	14.4	
Length of gestation:								
Less than 37 weeks	11.7	13.8	10.3	≤ .05	10.9	14.6	8.4	≤ .05
37 weeks or more	14.5	17.5	12.0	≤ .05	15.8	19.0	12.8	≤ .05

[1] Rates are first cesarean deliveries per 100 deliveries, excluding all repeat cesareans.
[2] Denotes a statistically significant difference across categories for "EFM" and "No EFM" comparisons.
[3] Family income is for married mothers only.
NOTE: NA = not applicable.

'Has the increased use of EFM contributed to the rising cesarean section rate? These two procedures have been successfully used to improve pregnancy outcome, but concern has been expressed over the increasing use of electronic technology and surgery in the birthing process.'

in association with EFM use was observed for all 35 maternal and infant characteristics considered, and 27 of 35 comparisons were statistically significant. For mothers delivering first infants stillborn, the primary cesarean rate was 13.6—17.2 when EFM was used and 10.7 when it was not. Again, the primary cesarean rate was higher when EFM was used for nearly all maternal and infant characteristics considered, and statistical significance was attained in 18 of 29 comparisons. This finding tenuously supports the notion that EFM is associated with a higher probability of primary cesareans performed in connection with stillbirths.

Discussion

EFM was introduced two decades ago and is now used for almost half of pregnancies that end in live-born or stillborn deliveries. When EFM was first introduced, less than 5 percent of deliveries were by cesarean section; by 1980, the percentage of deliveries by cesarean had more than tripled. This study suggests that EFM is associated with an increased risk of primary cesarean delivery. By no means, however, is increased use of EFM the only factor pointing to a rise in the cesarean section rate; a variety of other factors have been identified in recent years.

Some researchers have found that EFM improves fetal outcome in high-risk pregnancies (*1*) and reduces the intrapartum stillbirth rate (*20,21*). It has even been argued that universal use of EFM in low-risk pregnancies is safe and should be considered, partly because more unrecognized high-risk pregnancies could be better assessed (*22*).

On the other hand, Banta and Thacker (*11*) have identified risks to mother and infant from the use of EFM, such as laceration of the infant by either the electrode or the knife that punctures the infant's scalp, lacerations of the mother or her placenta from the electrodes, uterine infection, and uterine perforations from the catheter. They have also stressed that cesarean section is associated with higher maternal morbidity and mortality. However, a randomized trial found that no beneficial *or* deleterious effects of continuous fetal heart rate monitoring in labor occurred (*23*). Similarly, a prospective clinical and microbiological study found that women for whom internal monitoring was performed had no increase in frequency or severity of infection (*24*). These references serve to mirror the controversy that still surrounds EFM and cesarean delivery as increasingly popular interventions used by the obstetrical community.

It has been argued that a higher cesarean rate is to be expected with EFM use, since women with high-risk pregnancies are more likely to be monitored (*14*). This study shows that EFM is not necessarily used more often when a maternal or an infant characteristic is indicative of a high-risk pregnancy. However, for almost *all* characteristics (those related to both high- and low-risk pregnancies), the probability of cesarean delivery was higher with EFM use. However, our findings for stillbirths require particular caution in interpretation, because EFM may have been used to confirm fetal demise and the cesarean section may have been done simply to terminate the pregnancy. Furthermore, our study does not address infant health as a result of the use of EFM with or without cesarean section, and this type of investigation is needed to evaluate relative risks and benefits. According to one study of almost 400,000 singleton births and neonatal deaths in Georgia, it was estimated that if all breeches and high-risk, low-weight vertex infants had been delivered by cesarean section, an additional 5,206 cesareans would have been performed, 172 infants would have been saved, and three additional maternal deaths would have occurred (*25*).

We can support association, but not causation, in the relationship between EFM and cesarean section. It is often difficult to untangle whether it is the monitoring that is responsible for the cesarean or it is the high-risk pregnancy that is being monitored. On the face of it, the sequelae for some risk factors may seem clear. For example, patients with longer labors are more likely to be monitored, and prolonged labor is an indication for cesarean delivery. While it might be reasonable to argue that the monitoring would not be a factor in the likelihood of cesarean delivery in this case, why, then, do we find a higher cesarean rate for women with labor durations of 12 hours or more *if they were monitored?*

Cross-sectional data such as ours are rarely adequate for definitive answers to such complex questions, but they do provide enough circumstantial evidence to warrant multivariate analyses with greater attention to confounding risk factors, including the fetal indications for

cesarean section. Given these limitations, the present article should be regarded as a descriptive presentation of new data on fetal monitoring and cesarean delivery, not a definitive statement of cause and effect. Because of the descriptive nature of this investigation, our findings concerning the association between EFM use and cesarean delivery can only be suggestive, but they are consistent with those of Haverkamp and associates (*26*). We therefore ask the reader to reflect upon their recommendation:

Clearly, more controlled, well-designed perinatal studies (including long-term follow-up) are needed to evaluate the proper clinical role of electronic fetal monitoring. It has never been more important to separate the needed technology from the extraneous technology. More information and more sophisticated techniques do not necessarily improve outcomes. The support of both the public and the medical community is needed for more randomized prospective controlled studies to provide evidence which will allow both the physician and the patient to make informed, reasoned decisions on the effectiveness of various medical interventions (*26a*).

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